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20 MAY 1999

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1.	**Your reference**	49.70123
2.	**Patent application number** *(The Patent Office will fill in this part)*	**9911789.7**
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Cambridge Consultants Limited Science Park Milton Road Cambridge CB4 4DW
	Patents ADP number *(if you know it)*	361618001
	If the applicant is a corporate body, give country/state of incorporation	England
4.	**Title of the invention**	Electroluminescent Devices
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	**If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and** *(if you know it)* **the or each application number**			

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7.	**If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application**		

8.	**Is a statement of inventorship and of right to grant of a patent required in support of this request?** *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

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Continuation sheets of this form	
Description	12
Claim(s)	2
Abstract	1
Drawing(s)	2 + 2

10. **If you are also filing any of the following, state how many against each item.**

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. **I/We request the grant of a patent on the basis of this application.**

Signature [signature] **Date** 20 May 1999

12. **Name and daytime telephone number of person to contact in the United Kingdom**

P. Matthew Dixon
0171 206 0600

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Electroluminescent Devices

The present invention relates to electroluminescent devices, such as electroluminescent displays and electroluminescent lamps, and in particular to electroluminescent displays.

Electroluminescence is the emission of light by a material when subjected to an electric field. Phosphor electroluminescence was discovered and documented in 1936. However, it was only in the 1950's that GTE Sylvania received a patent for an electroluminescent powder lamp. The short lifetime, for example 500 hours, of such devices limited their usefulness.

Work carried out in the 1980's revitalised the powder electroluminescent lamp, and in 1990 the Durel Corporation demonstrated a flexible electroluminescent phosphor device that was incorporated as a backlight into a liquid crystal flat panel display. The manufacturing technique involved encapsulating the phosphor powder particles in glass beads and sandwiching the encapsulated powder between two electrodes, to which an AC voltage was applied to stimulate emission. Electroluminescent devices made according to this type of method are known as "thick film" or "powder" electroluminescent devices. This is to be contrasted with "thin film" electroluminescent devices, in the manufacture of which a thin layer of electroluminescent phosphor is deposited on a, typically glass, substrate by a method such as atomic layer epitaxy.

Traditionally, thin film technology has been used to make electroluminescent displays, and thick film technology has been used to make electroluminescent lamps, in particular backlights for liquid crystal displays (LCDs). An example of a thin film device is described in US Patent 5,463,279, and an example of a

thick film device is described in US Patent 5,686,792.

A typical thick film phosphor electroluminescent device comprises a layer of electroluminescent material in a dielectric matrix, sandwiched between two planar conducting electrodes. The electroluminescent material comprises phosphor particles, typically a zinc sulphide (ZnS) powder doped with manganese (Mn), microencapsulated in a dielectric material. Typically, silver- or graphite-loaded screen-printable inks, and indium tin oxide (ITO), a transparent conductive material, respectively are used to form the electrodes on a substrate such as a polyester film. When an AC voltage is applied between the electrodes, the electroluminescent material emits light.

The inventor has developed recently thick film electroluminescent displays in which a plurality of independent electrodes are provided on one side of the layer of electroluminescent material, opposite a common transparent electrode. A voltage may be applied selectively to each of these independent electrodes to illuminate a respective region of the display. A thick film electroluminescent display is created by selecting the configuration of the independent electrodes to represent information, for example in the form of a seven-segment display or the like.

A problem associated with the manufacture of thick film electroluminescent displays is that the independent electrodes must be connected electrically to a voltage source for the display. In a convenient manufacturing technique, electrical connections are applied as conductive tracks on the rear surface of the device, for example by screen printing conductive ink. However, the tracks themselves can act as electrodes and cause the electroluminescent phosphor to emit light where the phosphor is sandwiched between the common transparent electrode and the conductive track. Thus, the conductive tracks appear as illuminated lines on the

display and adversely affect the clarity of the displayed information, which is undesirable.

US Patent 5,686,792 relates to an electroluminescent lamp with a continuous electroluminescent dielectric layer and a patterned rear electrode overlying the electroluminescent dielectric layer. The rear electrode includes at least two conductive segments separated by a gap. An insulating layer fills the gap and a conductive interconnect overlies the insulating layer, joining the segments. The insulating layer spaces the interconnect from the electroluminescent dielectric layer, a sufficient distance to reduce the electric field in the electroluminescent dielectric layer below the point at which the lamp appears luminous.

The solution to the problem of visible electrical interconnections in the context of an electroluminescent lamp provided by US 5,686,792 has certain disadvantages. For example, the depth of the insulating layer is fixed by the manufacturing process and this depth determines a maximum voltage which can be applied to the rear electrode without causing illumination of the electrical connections in the electroluminescent display. Furthermore, the thickness of the insulating layer must be carefully controlled to ensure the invisibility of the interconnections, and this places additional constraints on the manufacturing process.

The present invention seeks to provide a novel configuration of an electroluminescent device in which the electrical connections to the electrodes of the device are not visible as illuminated regions of the electroluminescent material.

Viewed from a first aspect therefore the invention provides an electroluminescent device comprising:

a first, transparent electrode;

at least one second electrode;

a layer of electroluminescent material located

between the first and second electrodes; and

an electrical conductor electrically connected to the second electrode and arranged to supply, in use, a driving voltage for the electroluminescent material to the second electrode,

wherein an electrically conductive layer is provided between the electroluminescent material layer and the electrical conductor, said conductive layer being electrically connected to the first electrode, such that the potential difference across the electroluminescent material layer in the region of the electrical conductor is substantially zero.

Thus according to the invention, in the region of the electrical conductor, the electrically conductive layer ensures that there is substantially no potential difference across the electroluminescent material layer, even if the electrical conductor is supplying the driving voltage to the second electrode(s), and the electrical conductor therefore does not cause the electroluminescent material to illuminate.

The electroluminescent device may be an electroluminescent lamp. Preferably, however, the device is an electroluminescent display.

The first electrode may comprise a layer of a transparent conductive material, for example indium tin oxide, applied to a transparent substrate, for example a polyester film. The transparent conductive material may be applied to the transparent substrate by any suitable method, for example screen printing, sputtering and the like.

The device may comprise a plurality of second electrodes, preferably arranged to form a display. In a preferred arrangement, the configuration of the second electrodes is such that information can be represented by the display by the application of a voltage to selected second electrodes. For example the second electrodes may be arranged in a numeric or alphanumeric

display arrangement, such as a seven, fourteen or sixteen segment display.

The second electrodes may be provided on the device by any suitable method, such as by screen printing with conductive, for example silver- or graphite-loaded, inks.

The electroluminescent material may be a thin film phosphor layer. Preferably, however, the electroluminescent material is a thick film phosphor layer, for example zinc sulphide powder doped with manganese and microencapsulated in a dielectric material.

The electrical conductor may simply be a wire or the like connected to the second electrode(s). Preferably, however, the electrical conductor is in the form of a conductive track. The conductive track may be formed on the device by any suitable method, such as by screen printing with conductive, for example silver- or graphite-loaded, inks. Feasibly, the conductive track may be formed on the device together with the second electrode(s). In this case, the conductive track may be considered as an extension of the second electrode. The conductive track may be integral with the second electrode.

The electrical conductor may be arranged to connect electrically the second electrode to an interface portion of the device. In general, a respective electrical conductor is provided for each second electrode.

The conductive layer may be arranged in substantially the same plane as the second electrode(s). Thus, for example, the second electrode(s) may be provided in one or more voids or recesses defined in the conductive layer. In this case, the spacing between the conductive layer and the second electrodes, defined by the size of the voids, should be selected to prevent arcing due to potential differences between the

conductive layer and the second electrode(s).

A dielectric layer may be provided to insulate electrically the electrical conductor(s) from the conductive layer, as there may be a significant potential difference between these two components. Thus, such a dielectric layer must have sufficient electrical insulation capability to withstand the driving voltage for the electroluminescent material. The dielectric layer may be applied by any suitable method, such as screen printing.

In a preferred arrangement, the conductive layer is provided over the second electrode(s). This arrangement has the advantage that the registration of the conductive layer relative to the second electrode(s) does not need to be as accurate to ensure correct electrical functioning of the device as when the second electrode(s) are provided in voids or recesses in the conductive layer.

A dielectric layer may be provided to electrically insulate the second electrode(s) from the conductive layer, which will generally be at different potentials in use of the device. Such a dielectric layer may be applied by any suitable method, for example screen printing.

The conductive layer and/or the associated dielectric layer(s) may extend over substantially the entire area of the device, save for regions where the electrical conductor(s) connect to the second electrode(s). Voids may be defined in the conductive layer and/or the associated dielectric layer(s) through which the electrical conductor(s) may connect to the second electrode(s). However, such voids should be made as large as possible in order to minimise the effect of any mis-registration of the conductive layer (and/or the associated dielectric layer(s)), the second electrodes and the electrical conductor(s).

It is advantageous, therefore, for the conductive

layer to follow substantially the path of the electrical conductor(s), in order to reduce the cost of materials and to prevent the registration problems associated with voids in the conductive layer and/or the associated dielectric layer(s). It is desirable for the dielectric layer(s) to cover a greater area than the conductive layer, so that electrical insulation is generally assured even in the case of variations in the registration of these layers. Likewise, it is desirable for the conductive layer to cover a greater area than the electrical conductor(s), so that the electrical conductor(s) are generally not visibly illuminated even in the case of variations in the registration of the conductive layer relative to the electrical conductor(s).

Preferably, the conductive layer and the associated dielectric layer(s) overlap the area of the second electrode(s) in order to allow for tolerances in the registration of the conductive layer and the associated dielectric layer(s) relative to the electrical conductor(s).

However, the overall area of the conductive layer and the associated dielectric layer(s) is preferably maintained as small as possible to minimise the probability of a short circuit due to imperfections, such as pin holes, in the dielectric layer(s).

Although only a single conductive layer has been described above, the conductive layer may comprise a plurality of separate portions, each electrically connected to the first electrode.

In advantageous embodiments, at least one of the electrodes of the electroluminescent device, or the conductive layer, or the electrical conductors may be formed as a conductive track on a printed circuit board, preferably a flexible printed circuit board.

According to a further aspect of the invention, it is possible to prevent the unwanted illumination of the

electrical conductors without the use of a conductive layer as described above.

Viewed from a second aspect therefore the invention provides an electroluminescent device comprising:

a first, transparent electrode;

at least one second electrode;

a layer of electroluminescent material located between the first and second electrodes; and

an electrical conductor electrically connected to the second electrode and arranged to supply, in use, a driving voltage for the electroluminescent material to the second electrode,

wherein a void is defined in the first electrode corresponding substantially to the location of the electrical conductor.

Thus, according to this aspect of the invention a void (or gap) is provided in the first electrode opposite the electrical conductor, so that an electric field is not generated between the first electrode and the electrical conductor, which would cause the electroluminescent material to illuminate in the region of the electrical conductor.

Many of the preferred features described in relation to the first aspect of the invention may be applied also to the second aspect. In particular, the first electrode may comprise a layer of a transparent conductive material, for example indium tin oxide, applied to a transparent substrate, for example a polyester film. The transparent conductive material may be applied to the transparent substrate by any suitable method, for example screen printing, sputtering and the like. The void(s) may be defined in the first electrodes by etching the transparent conductive material from the transparent substrate. Alternatively, the transparent conductive material may be applied to the transparent substrate in a configuration which defines the void(s).

According to the invention, electroluminescent devices may be made which are flexible, lightweight and relatively inexpensive. Advantageously, an electroluminescent display may be incorporated into an item of clothing.

Thus, viewed from a third aspect the invention provides an item of clothing comprising an electroluminescent display.

The electroluminescent display may be arranged to display information relating to the wearer of the clothing. For example, the display may represent an amount of oxygen which remains in the tanks of breathing apparatus used by a firefighter or a diver. Similarly, the display could represent the elapsed time from the start of a race for a particular athlete.

The electroluminescent display may include additional electronics for controlling the display. For example, the display may include short range communication electronics for example utilising the DECT or Blue Tooth communications protocols.

The electroluminescent display may comprise a first electrode, a plurality of second electrodes, and a layer of electroluminescent material located between the first and second electrodes. Advantageously, the electroluminescent display may comprise an electroluminescent device according to the first or second aspects of the invention.

Although the invention has been described in terms of the structure of an electroluminescent device, the invention also extends to a method of making such a device as described herein.

Some embodiments of the invention will now be described by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of an electroluminescent device according to the invention; and

Figure 2 is an exploded view of the device of Figure 1.

As shown in Figure 1 an electroluminescent device according to the invention comprises a substrate layer 1 of transparent polyester, which is prefabricated with a layer of indium tin oxide (ITO) 2 to form a first, transparent electrode. A layer of thick film electroluminescent phosphor material 3 is provided on top of the ITO layer 2. A first dielectric layer 4 is provided over the phosphor layer 3, and on top of the first dielectric layer 4 is provided a second electrode 5 of screen-printed silver-loaded ink. The second electrode 5 is covered by a second dielectric layer 6. The second dielectric layer 6 electrically isolates the second electrode 5 from a conductive layer (or backplane) 7, also of screen-printed silver-loaded ink. On top of the backplane layer 7 is provided a third dielectric layer 8, which electrically isolates the backplane layer 7 from an electrical conductor in the form of a conductive track 9.

As shown in Figure 1, the backplane layer 7 is electrically connected to the ITO layer 2 so that these two layers are always at the same electrical potential. A void is defined through each of the third dielectric layer 8, the backplane layer 7, and the second dielectric layer 6, so that an electrical connection can be made between the conductive track 9 and the second electrode 5.

In use, an AC driving voltage of 100 to 600 volts is applied between the second electrode 5 (via the conductive track 9) and the ITO layer 2, in order to generate an electric field across the electroluminescent phosphor 3 so that the phosphor emits light.

The conductive backplane layer 7 is always at substantially the same electrical potential as the ITO layer 2, and is located between the phosphor layer 3 and the conductive track 9. There is therefore no electric

field across the electroluminescent phosphor layer 3 due to the driving voltage in the conductive track 9. In effect, the backplane layer 7 shields the electroluminescent phosphor layer 3 from the driving voltage in the conductive track 9, so that the phosphor layer 3 is not illuminated by the conductive track 9.

Although the third dielectric layer 8, the backplane layer 7, and the second dielectric layer 6, are represented in Figure 2 as having voids defined therein for the conductive track 9, it is preferred for the third dielectric layer 8, the backplane layer 7, and the second dielectric layer 6 to follow substantially the path of the conductive track 9, in order to reduce the cost of materials and to prevent registration problems between these layers.

In summary, an electroluminescent device comprises a first, transparent electrode 1,2, a second electrode 5, and a layer of electroluminescent material 3 located between the first and second electrodes. A conductive track 9 is electrically connected to the second electrode 5 and supplies a driving voltage for the electroluminescent material 3 to the second electrode 5. An electrically conductive layer 7 is provided between the electroluminescent material layer 3 and the conductive track 9, and is electrically connected to the first electrode 1,2, such that the potential difference across the electroluminescent material layer 3 in the region of the conductive track 9 is substantially zero. In this way, when the conductive track 9 is supplying the driving voltage to the second electrode 5, the electroluminescent material layer 3 is not illuminated by an electric field between the conductive track 9 and the first electrode 1,2.

In an alternative arrangement (not shown), there is no conductive layer 7, and a gap is defined in the first electrode 1,2 corresponding substantially to the location of the conductive track 9. This also prevents

the voltage in the conductive track 9 from illuminating the electroluminescent material layer 3.

An electroluminescent display may be included in an item of clothing.

Claims

1. An electroluminescent device comprising:

a first, transparent electrode;

at least one second electrode;

a layer of electroluminescent material located between the first and second electrodes; and

an electrical conductor electrically connected to the second electrode and arranged to supply, in use, a driving voltage for the electroluminescent material to the second electrode,

wherein an electrically conductive layer is provided between the electroluminescent material layer and the electrical conductor, said conductive layer being electrically connected to the first electrode, such that the potential difference across the electroluminescent material layer in the region of the electrical conductor is substantially zero.

2. A device as claimed in claim 1, wherein the electrical conductor is in the form of a conductive track.

3. A device as claimed in claim 1 or 2, wherein the conductive layer follows substantially the path of the electrical conductor.

4. A device as claimed in any preceding claim, further comprising a first dielectric layer located between the electrical conductor and the conductive layer, and a second dielectric layer located between the second electrode and the conductive layer, wherein the conductive layer and the first and second dielectric layers overlap the area of the second electrode.

5. An electroluminescent device comprising:

a first, transparent electrode;

at least one second electrode;

a layer of electroluminescent material located between the first and second electrodes; and

an electrical conductor electrically connected to the second electrode and arranged to supply, in use, a driving voltage for the electroluminescent material to the second electrode,

wherein a void is defined in the first electrode corresponding substantially to the location of the electrical conductor.

6. A device as claimed in any preceding claim, wherein at least one of the second electrode, the conductive layer and the electrical conductor is formed as a conductive track on a printed circuit board.

7. An item of clothing comprising an electroluminescent display.

8. An item of clothing as claimed in claim 7, wherein the electroluminescent display comprises a first electrode, a plurality of second electrodes, and a layer of electroluminescent material located between the first and second electrodes.

9. An item of clothing as claimed in claim 7 or 8, wherein the electroluminescent display comprises an electroluminescent device as claimed in any of claims 1 to 6.

10. An electroluminescent device substantially as hereinbefore described with reference to the drawings.

Abstract

Electroluminescent Devices

An electroluminescent device comprises a first, transparent electrode 1,2, a second electrode 5, and a layer of electroluminescent material 3 located between the first and second electrodes. A conductive track 9 is electrically connected to the second electrode 5 and supplies a driving voltage for the electroluminescent material 3 to the second electrode 5. An electrically conductive layer 7 is provided between the electroluminescent material layer 3 and the conductive track 9, and is electrically connected to the first electrode 1,2, such that the potential difference across the electroluminescent material layer 3 in the region of the conductive track 9 is substantially zero. In this way, when the conductive track 9 is supplying the driving voltage to the second electrode 5, the electroluminescent material layer 3 is not illuminated by an electric field between the conductive track 9 and the first electrode 1,2.

In an alternative arrangement, there is no conductive layer 7, and a gap is defined in the first electrode 1,2 corresponding substantially to the location of the conductive track 9. This also prevents the voltage in the conductive track 9 from illuminating the electroluminescent material layer 3.

An electroluminescent display may be included in an item of clothing.

[Fig. 1]

1/2

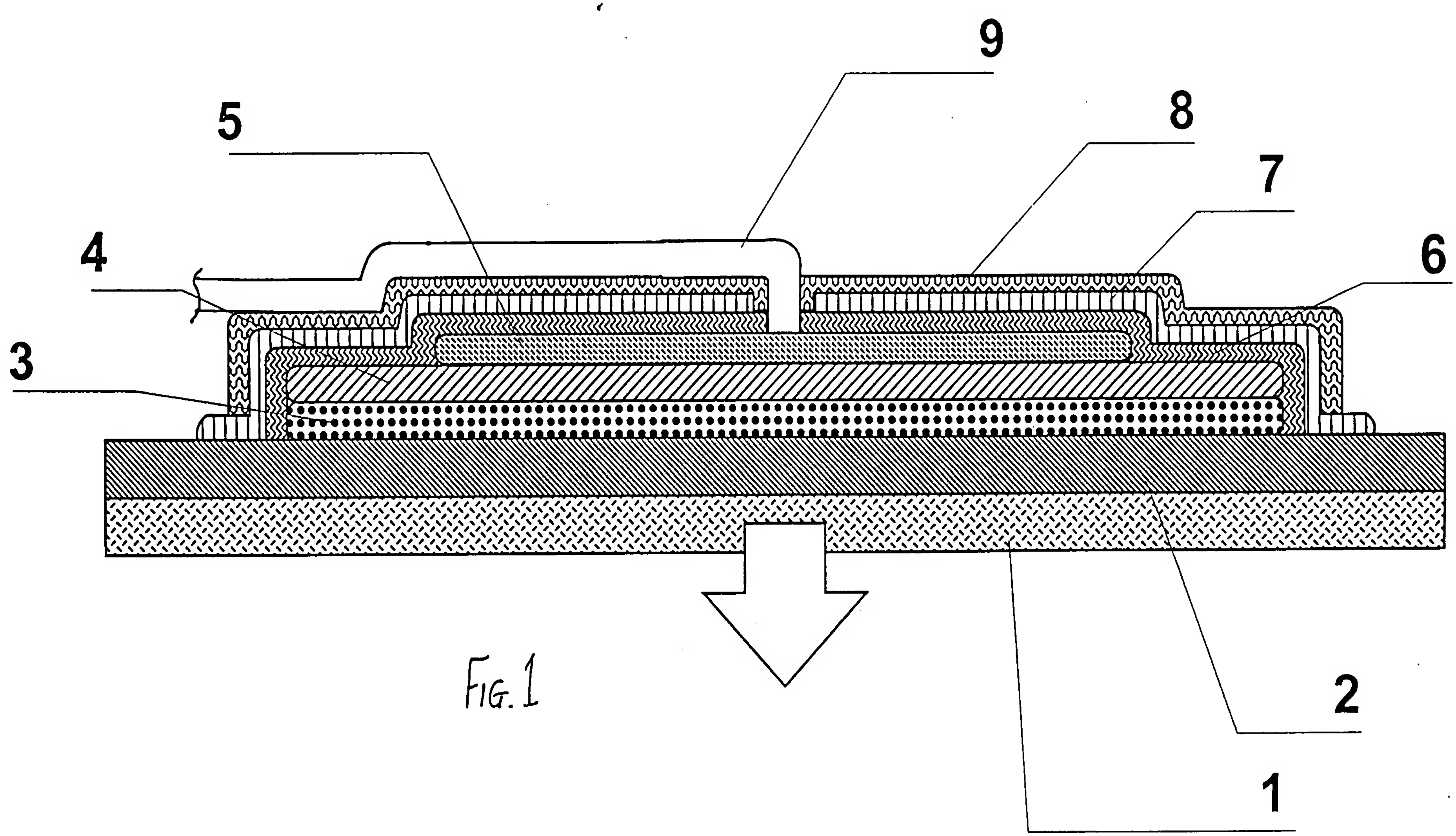

FIG. 1

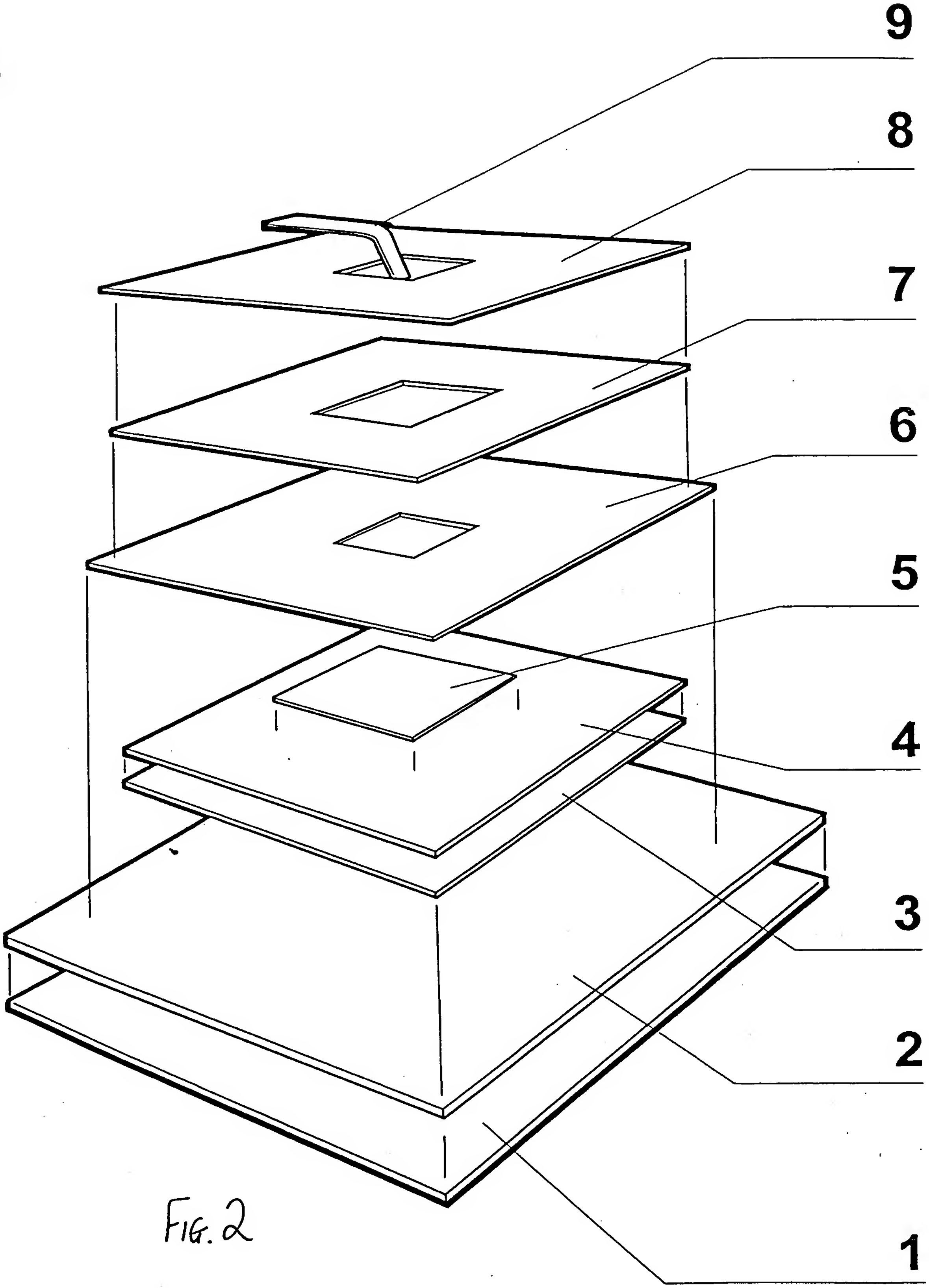

FIG. 2